CHAPTER 2 (Odd)

3. a. $r = 1\text{ m}: F = \dfrac{kQ_1Q_2}{r^2} = \dfrac{(9 \times 10^9)(1\ \mu\text{C})(2\ \mu\text{C})}{(1\text{ m})^2}$

$= \dfrac{(9 \times 10^9)(2 \times 10^{-12})}{1} = \dfrac{18 \times 10^{-3}}{1} = \mathbf{18\ mN}$

b. $r = 3\text{ m}: F = \dfrac{18 \times 10^{-3}}{(3)^2} = \dfrac{18 \times 10^{-3}}{9} = \mathbf{2\ mN}$

c. $r = 10\text{ m}: F = \dfrac{18 \times 10^{-3}}{(10)^2} = \dfrac{18 \times 10^{-3}}{100} = \mathbf{180\ \mu N}$

5. $F = \dfrac{kQ_1Q_2}{r^2} = \dfrac{(9 \times 10^9)(2\text{ mC})(4\ \mu\text{C})}{r^2} = \dfrac{72}{r^2}$

$r = 0.5\text{ m}, F = \dfrac{72}{(0.5)^2} = \mathbf{288\ N}$

$r = 1\text{ m}, F = \dfrac{72}{(1)^2} = \mathbf{72\ N}$

$r = 5\text{ m}, F = \dfrac{72}{(5)^2} = \mathbf{2.88\ N}$

$r = 10\text{ m}, F = \dfrac{72}{(10)^2} = \mathbf{0.72\ N}$

7. $F = \dfrac{kQ_1Q_2}{r^2} \Rightarrow 1.8 = \dfrac{kQ_1Q_2}{(2\text{ m})^2} \Rightarrow kQ_1Q_2 = 4(1.8) = 7.2$

a. $F = \dfrac{kQ_1Q_2}{r^2} = \dfrac{7.2}{(10)^2} = \mathbf{72\ mN}$

b. $Q_1/Q_2 = 1/2 \Rightarrow Q_2 = 2Q_1$

$7.2 = kQ_1Q_2 = (9 \times 10^9)(Q_1)(2Q_1) = 9 \times 10^9(2Q_1^2)$

$\dfrac{7.2}{18 \times 10^9} = Q_1^2 \Rightarrow Q_1 = \sqrt{\dfrac{7.2}{18 \times 10^9}} = \mathbf{20\ \mu C}$

$Q_2 = 2Q_1 = 2(2 \times 10^{-5}\text{ C}) = \mathbf{40\ \mu C}$

9. $I = \dfrac{Q}{t} = \dfrac{465\text{ C}}{(2.5)(60\text{ s})} = \mathbf{3.1\ A}$

11. $Q = It = (750 \times 10^{-3}\text{A})(120\text{ s}) = \mathbf{90\ C}$

13. 21.847×10^{18} electrons $\left[\dfrac{1\text{ C}}{6.242 \times 10^{18}\text{ electrons}}\right] = 3.5\text{ C}$

$I = \dfrac{Q}{t} = \dfrac{3.5\text{ C}}{7\text{ s}} = \mathbf{0.5\ A}$

15. $I = \dfrac{Q}{t} = \dfrac{86\text{ C}}{(1.2)(60\text{ s})} = 1.194\text{ A} > 1\text{A}$ **(yes)**

17. a. $Q = It = (2\text{ mA})(0.01\ \mu\text{s}) = 2 \times 10^{-11}\text{ C}$

$2 \times 10^{-11}\ \cancel{C}\left[\dfrac{6.242 \times 10^{18}\text{ electrons}}{1\ \cancel{C}}\right]\left[\dfrac{1\ ¢}{\text{electron}}\right]$

$= 1.248 \times 10^{8}\ ¢ = \$1.248 \times 10^{6} = \mathbf{1.248\ million}$

b. $Q = It = (100\ \mu\text{A})(1.5\text{ ns}) = 1.5 \times 10^{-13}\text{ C}$

$1.5 \times 10^{-13}\ \cancel{C}\left[\dfrac{6.242 \times 10^{18}\ \cancel{\text{electrons}}}{1\ \cancel{C}}\right]\left[\dfrac{\$1}{\cancel{\text{electron}}}\right] = \$936{,}300 = \mathbf{0.9363\ million}$

(a) > (b)

19. $W = VQ = (42\text{ V})(6\text{ C}) = \mathbf{252\ J}$

21. $Q = \dfrac{W}{V} = \dfrac{90\text{ J}}{22.5\text{ V}} = \mathbf{4\ C}$

23. $Q = It = \left[\dfrac{420\text{ C}}{\cancel{\text{min}}}\right](0.5\ \cancel{\text{min}}) = 210\text{ C}$

$V = \dfrac{W}{Q} = \dfrac{742\text{ J}}{210\text{ C}} = \mathbf{3.53\ V}$

25. $I = \dfrac{\text{Ah rating}}{t(\text{hours})} = \dfrac{200\text{ Ah}}{40\text{ h}} = \mathbf{5\ A}$

27. $t(\text{hours}) = \dfrac{\text{Ah rating}}{I} = \dfrac{32\text{ Ah}}{1.28\text{ A}} = \mathbf{25\ h}$

29. From Fig. 2.18a ≅ 425 mAh

$t(\text{hours}) = \dfrac{\text{mAh rating}}{I(\text{mA})} = \dfrac{425\text{ mAh}}{550\text{ mA}} = \mathbf{0.773\ h}$

31. 1 h: $I_1 = \dfrac{40\text{ Ah}}{1\text{ h}} = 40\text{ A}$

$I_2 = \dfrac{60\text{ Ah}}{1\text{ h}} = 60\text{ A}$

60 A: 40 A ⇒ 1.5:1 (50% more)

33. $I = \frac{3\ \text{Ah}}{5.5\ \text{h}} = 545.45\ \text{mA}$

$Q = It = (545.45\ \text{mA})(5.5\ \cancel{\text{h}})\left[\frac{60\ \cancel{\text{min}}}{1\ \cancel{\text{h}}}\right]\left[\frac{60\ \text{s}}{1\ \cancel{\text{min}}}\right] = 10{,}799.91\ \text{C}$

$W = QV = (10{,}799.91\ \text{C})(12\ \text{V}) \cong$ **129.6 kJ**

43. $4\ \cancel{\text{min}}\left[\frac{60\ \text{s}}{1\ \cancel{\text{min}}}\right] = 240\ \text{s}$

$Q = It = (2.5\ \text{A})(240\ \text{s}) =$ **600 C**

CHAPTER 2 (Even)

2. $F = \frac{kQ_1Q_2}{r^2} = \frac{(9 \times 10^9)(1.6 \times 10^{-19}C)^2}{(5 \times 10^{-11}\text{ m})^2}$

$= \frac{23.04 \times 10^9 \times 10^{-38}}{25 \times 10^{-22}} = \frac{23.04}{25} \times 10^{-7} = \mathbf{0.092\ \mu N}$

4. a. $r = 1$ mi:

$1\ \text{mi}\left[\frac{5280\ \text{ft}}{1\ \text{mi}}\right]\left[\frac{12\ \text{in.}}{1\ \text{ft}}\right]\left[\frac{1\ \text{m}}{39.37\ \text{in.}}\right] = 1609.35\ \text{m}$

$F = \frac{kQ_1Q_2}{r^2} = \frac{(9 \times 10^9)(8 \times 10^{-6}\ C)(40 \times 10^{-6}\ C)}{(1609.35\ \text{m})^2} = \frac{2880 \times 10^{-3}}{2.59 \times 10^6}$

$= \mathbf{1.11\ \mu N}$

b. $r = 0.01$ m:

$F = \frac{kQ_1Q_2}{r^2} = \frac{2880 \times 10^{-3}}{(10^{-2})^2} = \frac{2880 \times 10^{-3}}{10^{-4}} = 2880 \times 10^1 = \mathbf{28.8\ kN}$

c. $\frac{1\ \text{in.}}{16}\left[\frac{1\ \text{m}}{39.37\ \text{in.}}\right] = 1.59\ \text{mm}$

$F = \frac{kQ_1Q_2}{r^2} = \frac{2880 \times 10^{-3}}{(1.59 \times 10^{-3}\ \text{m})^2} = \frac{2880 \times 10^{-3}}{2.53 \times 10^{-6}} = 1138.34 \times 10^3\ \text{N}$

$= \mathbf{1138.34\ kN}$

6. $F = \frac{kQ_1Q_2}{r^2} \Rightarrow r = \sqrt{\frac{kQ_1Q_2}{F}} = \sqrt{\frac{(9 \times 10^9)(20 \times 10^{-6})^2}{3.6 \times 10^4}} = \mathbf{10\ mm}$

8. $I = \frac{Q}{t} = \frac{650\ C}{50\ s} = \mathbf{13\ A}$

10. $Q = It = (40\ A)(60\ s) = \mathbf{2400\ C}$

12. $t = \frac{Q}{I} = \frac{4600 \times 10^{-6}\ C}{2 \times 10^{-3}\ A} = \mathbf{2.3\ s}$

14. $Q = It = (1\ A)(60\ s) = 60\ C$

$60\ C = 60(6.242 \times 10^{18}\ \text{electrons}) = \mathbf{374.52 \times 10^{18}\ electrons}$

16. $0.784 \times 10^{18}\ \text{electrons}\left[\frac{1\ C}{6.242 \times 10^{18}\ \text{electrons}}\right] = 0.1256\ C$

$I = \frac{Q}{t} = \frac{0.1256\ C}{643 \times 10^{-3}\ s} = \mathbf{195\ mA}$

18. 50×10^{18} ~~electrons~~ $\left[\dfrac{1\text{ C}}{6.242 \times 10^{18}\text{ electrons}}\right] = 8.01\text{ C}$

$V = \dfrac{W}{Q} = \dfrac{96 \times 10^{-3}\text{ J}}{8.01\text{ C}} = \mathbf{11.985\text{ mV}}$

20. $Q = \dfrac{W}{V} = \dfrac{96\text{ J}}{16\text{ V}} = \mathbf{6\text{ C}}$

22. $Q = It = (200 \times 10^{-3}\text{ A})(30\text{ s}) = 6\text{ C}$

$V = \dfrac{W}{Q} = \dfrac{40\text{ J}}{6\text{ C}} = \mathbf{6.67\text{ V}}$

24. $Q = \dfrac{W}{V} = \dfrac{0.4\text{ J}}{24\text{ V}} = 0.0167\text{ C}$

$I = \dfrac{Q}{t} = \dfrac{0.0167\text{ C}}{5 \times 10^{-3}\text{ s}} = \mathbf{3.34\text{ A}}$

26. Ah = [0.8 A][76 h] = **60.8 Ah**

28. @ 100°F ≅ **475 mAh**
@ 0°C(32°F) ≅ **455 mAh**

30. From Fig. 2.19 ≅ 10.4 h @ 50 mA
≅ 3.4 h @ 150 mA
150 mA: 50 mA = 3:1
3.4 h: 10.4 h = 1:3

An increase in drain current by a factor of three decreases the time availability to about one-third.

32. For 1 hour, I = 500 mA

$Q = It = (500\text{ mA})(1\text{ h})\left[\dfrac{60\text{ min}}{1\text{ h}}\right]\left[\dfrac{60\text{ s}}{1\text{ min}}\right] = (500 \times 10^{-3}\text{ A})(3600\text{ s}) = 1800\text{ C}$

$W = VQ = (1.2\text{ V})(1800\text{ C}) = \mathbf{2160\text{ J}}$

44. $Q = It = (10 \times 10^{-3}\text{ A})(20\text{ s}) = \mathbf{200\text{ mC}}$

$W = VQ = (12.5\text{ V})(200 \times 10^{-3}\text{ C}) = \mathbf{2.5\text{ J}}$